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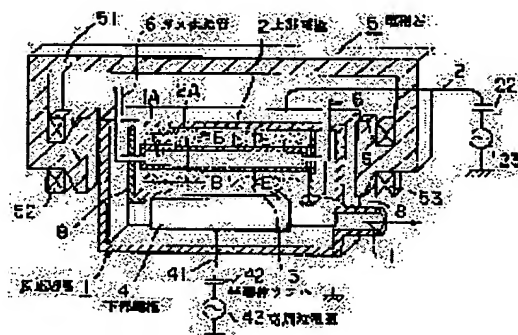
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(54) PLASMA PROCESSOR

(57)Abstract:

PURPOSE: To process a semiconductor wafer uniformly and besides at high speed by bringing homogeneous plasma into contact with the surface of a semiconductor wafer.

CONSTITUTION: This processor is equipped with a reactor 1, which forms vacuum space required for generation of plasma, an upper electrode 2, which is arranged above inside the reactor 1, a lower electrode 4, which is counterposed below the upper electrode 2 so as to oppose this and besides generates plasma by the vacuum discharge between it and the upper electrode 2 and doubles as a placing stage for a semiconductor wafer 3, and an electromagnet 5, which applies a magnetic field B orthogonal to the electric field between both these electrodes. This is so constituted as to form ring-shaped plasma, which surrounds the upper electrode 2 ranging over from the bottom to the top, by the magnetic field B applied by the electromagnet 5 and the electric fields made between each electrode 2 and 4, and also, bring this plasma into contact with the semiconductor wafer 3 on the lower electrode 4.



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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Industrial Application] This invention relates to plasma treatment equipment.

[0002]

[Description of the Prior Art] Vacuum discharge of the plasma treatment equipment is carried out within the processing container with which the gas for processing exists, and it generates the plasma, is equipment which performs predetermined processing to a processed object using this plasma, for example, is used from the former at the sputtering process in a semi-conductor production process, the ashing process, the CVD process, or the etching process. On the other hand, since multilayering and the semi-conductor wafer which it is made detailed and is a processed object further have diameter[of macrostomia]-ized [wiring structure] increasingly with high integration of a semi-conductor in recent years, the plasma treatment under low voltage called for example, homogeneity and 30mTorr is becoming a still more important technical problem.

[0003] So, with conventional plasma treatment equipment, in order to be stabilized and to generate the plasma under low voltage, the policy which shuts up the plasma around an electrode using a field, carries out densification of the plasma in the circumference of it, and carries out plasma treatment to homogeneity is taken. And as such a Prior art, there are some which were indicated by JP,59-140375,A and JP,61-86942,A, for example. The former carries a wafer on the magnetron electrode of a special structure, and it is made to confine the plasma in the perimeter, and the latter restricts the behavior of the electron of the electrode circumference and is made to carry out plasma treatment to homogeneity while it generates rotating magnetic field along the front face of an electrode.

[0004]

[Problem(s) to be Solved by the Invention] However, although the various devices which form the plasma of high density around an electrode as mentioned above were taken with conventional plasma treatment equipment in order to perform uniform plasma treatment to a processed object under low voltage, the technical problem that the field of homogeneity processing was not yet enough to cope with the inclination of high integration of a semi-conductor and diameter[of macrostomia]-izing of a processed object even if it is such plasma treatment equipment occurred.

[0005] This invention was made in order to solve the above-mentioned technical problem, and it aims at offering the plasma treatment equipment which the homogeneous plasma can be contacted on the front face of a processed object under low voltage, and can carry out plasma treatment of the processed object to homogeneity.

[0006]

[Means for Solving the Problem] The plasma treatment equipment of this invention according to claim 1 The processing container which forms vacuum space required for generating of the plasma, and the up electrode arranged above [in this processing container], The lower electrode which is besides made to counter this in the lower part of a section electrode, and is installed, and is made to generate the plasma by vacuum discharge between the above-

mentioned up electrodes and which served as the installation section of a processed object, It has a field impression means to impress the field which intersects perpendicularly to the electric field between these two electrodes. While forming the plasma of the shape of a ring which continues and encloses the above-mentioned up electrode on the top face from an inferior surface of tongue by the field impressed by the above-mentioned field impression means, and the electric field impressed to each above-mentioned inter-electrode one, it constitutes so that this plasma may be contacted on the processed object on the above-mentioned lower electrode.

[0007] Moreover, the plasma treatment equipment of this invention according to claim 2 controls the above-mentioned field impression means in invention according to claim 1, and it constitutes it so that the direction of a field may be reversed intermittently.

[0008] Moreover, the plasma treatment equipment of this invention according to claim 3 prepares and constitutes the elevator style in invention according to claim 1 or 2 which makes it go up and down the above-mentioned up electrode.

[0009] Moreover, the plasma treatment equipment of this invention according to claim 4 constitutes the magnitude of this supply voltage in adjustable while connecting a power source to the above-mentioned lower electrode in claim 1 thru/or invention according to claim 3.

[0010] Moreover, the plasma treatment equipment of this invention according to claim 5 is constituted so that the side on this top face of a processing container may be made to deflect the gas supply line in claim 1 thru/or invention according to claim 2 which supplies the gas for processing in the above-mentioned processing container and the gas for processing may be supplied from the side of the above-mentioned up electrode.

[0011]

[Function] If according to invention of this invention according to claim 1 the gas for processing is supplied in a processing container where a processed object is laid in the lower electrode in a processing container, a predetermined degree of vacuum is held and vacuum discharge is carried out between an up electrode and a lower electrode under such a condition While the plasma occurs between two electrodes by this vacuum discharge, vertical section inter-electrode electric field and the field impressed by the field impression means cross at right angles. The plasma which this rectangular electromagnetic field act on the plasma, and continue and go an up electrode around on the top face from an inferior surface of tongue, and forms the ring-like plasma and goes an up electrode around can contact homogeneity at the processed object on a lower electrode, and can carry out plasma treatment of the processed object to homogeneity.

[0012] Moreover, according to invention of this invention according to claim 2, the plasma which is made to reverse intermittently the magnetic pole of the above-mentioned field impression means, is made to reverse intermittently the circumference direction of the plasma which goes an up electrode around by this, and contacts a processed object can be homogenized.

[0013] Moreover, according to invention of this invention according to claim 3, you can make it able to go up and down the above-mentioned up electrode by the elevator style, and the distance of an up electrode and a lower electrode can be suitably set up according to the contents of plasma treatment.

[0014] Moreover, according to invention of this invention according to claim 4, according to the class of the above-mentioned processed object, the applied voltage of the electrode by the power source can be changed suitably, and the optimal plasma treatment for a processed object can be performed.

[0015] Moreover, according to invention of this invention according to claim 5, the above-mentioned gas supply line deflects to the side on the top face of a processing container, a top face can be covered from an inferior surface of tongue in the above-mentioned up electrode, and homogeneity can be made to go the plasma around by supplying the gas for processing from the side of the above-mentioned up electrode.

[0016]

[Example] The example shown in drawing 1 - drawing 4 is based hereafter, and this invention is explained.

[0017] The interior of the reaction container 1 as a processing container which the plasma

treatment equipment of this example forms vacuum space required for generating of the plasma as shown in drawing 1 , for example, carried out alumite processing of the front face of aluminum is constituted so that it may operate as earth electrode 1A of plasma generating. And the up electrode 2 with which this plasma treatment equipment was arranged above [in the above-mentioned reaction container 1], the lower part of the besides section electrode 2 — this being made to counter, and it being arranged in parallel, and the plasma by vacuum discharge being generated between the above-mentioned up electrodes 2, and with the processed object 4, for example, the lower electrode which served as the installation section which holds the semi-conductor wafer 3 horizontally It has the electromagnet 5 as a field impression means to impress the field B which intersects perpendicularly to these two electrodes 2 and the electric field E between four in the upper part of the above-mentioned lower electrode 4, and is constituted. Moreover, this plasma treatment equipment is constituted so that this plasma may be contacted to the semi-conductor wafer 3 on the above-mentioned lower electrode 4, while forming the plasma of the shape of a ring which continues and encloses the above-mentioned up electrode 2 on the top face from an inferior surface of tongue by the field B impressed by the above-mentioned electromagnet 5, and the above-mentioned two electrodes 2 and the electric field E impressed among four.

[0018] When the above-mentioned plasma treatment equipment is explained further in full detail, so, in the right-and-left side edge section of the reaction container 1 above-mentioned top face the inside of the reaction container 1 by which vacuum suction was carried out — the gas for processing (for example, chlorine-based gas, such as chlorine, --) Two or more gas supply lines 6 used in case it is independent respectively, or fluorine system gas, such as trifluoromethane, etc. and inert gas, such as an argon, are mixed and it supplies penetrate to bilateral symmetry, respectively. It is constituted so that the gas for processing may be supplied to the interior of the above-mentioned reaction container 1 and plasma treatment of the above-mentioned semi-conductor wafer 2 may be carried out by these gas supply lines 6. Moreover, the exhaust port 11 which discharges the generation gas after plasma treatment is formed in the side face of this reaction container 1.

[0019] Moreover, the up electrode 2 arranged in the above-mentioned reaction container 1 is formed in the shape of [flat] a rectangle case with electrode materials, such as aluminum, and is connected to the blocking capacitor 22 and RF generator 23 through wiring 21. and — the right-and-left both-sides side of this up electrode 2 — the above-mentioned reaction container 1 — from that outside -- since -- the above-mentioned gas supply line 6 penetrated inside is connected by the conclusion member of bolt 25 grade through the insulating material 24 of ceramics, such as an alumina, respectively by that flange 6A (refer to drawing 2). Moreover, much hole 2A is formed in the inferior surface of tongue of this up electrode 2, and it is constituted so that the gas for processing introduced by the above-mentioned gas supply line 6 from the both-sides side of the up electrode 2 may be caudad turned from hole 2A of above-mentioned a large number, may be made to blow off equally and it may distribute broadly within the above-mentioned reaction container 1. Furthermore, as shown in drawing 2 , this electrode 2 is connected with the elevator style 7 equipped with the motor 71 through the above-mentioned gas supply line 6, and it is constituted so that it may go up and down in this ***** direction within the above-mentioned reaction container 1 and the distance between the above-mentioned lower electrodes 4 can be suitably set up according to the contents of plasma treatment by the drive of the motor 71 of this elevator style 7.

[0020] On the other hand, the lower electrode 4 arranged under the above-mentioned up electrode 2 is formed with electrode materials, such as aluminum, and the cooling means (not shown) through which refrigerants, such as liquefaction nitrogen, circulate on the inferior surface of tongue is unified. Moreover, it connects with the above-mentioned electrode 4 through wiring 41 at a blocking capacitor 42 and RF generator 43, and it is constituted so that the adjustable control of the electrical potential difference moreover impressed to the above-mentioned electrode 4 can be suitably carried out with armature-voltage control equipment (not shown) according to the contents of processing of the semi-conductor wafer 3. And where high-frequency voltage is impressed, the auto-bias of the above-mentioned electrode 4 is carried out

to negative by the blocking capacitor 42 at the time of plasma generating. In addition, although not illustrated, a matching circuit is connected to the above-mentioned electrode 4, and the applied voltage of the above-mentioned lower electrode 4 is stabilized by this matching circuit. [0021] Moreover, N pole is formed with a coil 52 and the electromagnet 5 arranged in the exterior of the above-mentioned reaction container 1 forms the south pole with the coil 53 while having the coils 52 and 53 attached in the both ends in gate type York 51 which consists of magnetic materials, such as a yoke, and this York 51, as shown in drawing 1. And as for this electromagnet 5, that York 51 crosses the center of that depth direction right and left in the above-mentioned reaction container 1 upper part, N pole is located in the left of the above-mentioned reaction container 1, and the south pole is located in the method of the right of the above-mentioned reaction container 1. Therefore, this electromagnet 5 is constituted so that the parallel field B can be impressed to each side of the field 2 and B 4, i.e., each above-mentioned electrodes, which is energized and goes to the method of the right horizontally from that left inside the above-mentioned reaction container 1. Furthermore, this electromagnet 5 is constituted so that the direction where a current flows may be changed, each polarity may be reversed intermittently and the sense of Field B may be intermittently reversed with the control unit which is not illustrated.

[0022] Thus, each electrode 2, the electric field E impressed among four, and the above-mentioned field B cross at right angles, when high-frequency voltage is impressed to the two electrodes 2 and 4 of the above-mentioned vertical section, respectively. By this rectangular electromagnetic field, make it go around in the direction of an arrow head which carries out induction of the $E \times B$ drift motion to the electron and ion particle in these two electrodes 2 and the plasma generated among four, and shows the plasma by drawing 3, and cover a top face from that inferior surface of tongue, and the up electrode 2 is surrounded in the shape of a ring. The plasma which contacts the lower electrode 4 by the inferior-surface-of-tongue side of the up electrode 2 is generated. moreover, area boils markedly the top face of the above-mentioned up electrode 2 from the inferior surface of tongue in which much hole 2A was formed, and since it is large, the strong plasma is formed by high density between this top face and the reaction container 1. And it can be intermittently reversed as mentioned above, and this field B can reverse intermittently the migration direction of the electron in the plasma, and an ion particle, and can homogenize the distribution condition in the inside of the plasma of an electron and an ion particle by this.

[0023] Furthermore, the plasma shielding plates 8 and 8 which the both-sides side of right and left of the above-mentioned up electrode 2 was made to counter these, for example, were formed in it of the insulating material of ceramics, such as an alumina, are arranged through a clearance, respectively, and it is constituted so that the plasma may not make it spread to right and left of each above-mentioned electrodes 2 and 4 with both [these] the plasma shielding plates 8 and 8. In addition, in case the above-mentioned up electrode 2 goes up and down, the notch (not shown) of the longwise configuration which the above-mentioned gas supply line 6 passes is formed in this plasma shielding plate 8.

[0024] Next, actuation of etching using the above-mentioned plasma treatment equipment is explained. First, the semi-conductor wafer 3 is carried in using the conveyance device which opens wide the breaker style which the reaction container 1 does not illustrate, and is not illustrated from a load lock chamber. This semi-conductor wafer 3 is laid in the top face of an electrode 4 the appropriate back. Then, a breaker style is operated, the reaction container 1 is sealed, the interior is changed into an airtight condition, and the interior is made into a predetermined vacua.

[0025] The up electrode 2 is dropped by the elevator style 7 the appropriate back, the clearance between the inferior surface of tongue of this up electrode 2 and the lower electrode 4 is set as about 10mm, for example, chlorine gas is supplied as etching gas from the gas supply line 6 of the reaction container 1, and that gas pressure is adjusted to for example, 10-2Torr. While impressing high-frequency voltage to the up electrode 2 and the lower electrode 4 by RF generators 23 and 43 in parallel to this, the field B which energizes an electromagnet 5 and goes to the method of the right from the left first within the reaction container 1 is impressed.

[0026] While glow discharge occurs between the two electrodes 2 of the vertical section, and 4 and the plasma of chlorine gas occurs between two electrodes 2 and 4 by this as a result of above-mentioned actuation Rectangular electromagnetic field are formed in a plasma field by the field B which intersects perpendicularly these both 2, the electric field E between four, and this. Induction of the $E \times B$ drift motion is carried out to the electron and ion particle in the plasma by this electromagnetic field. Especially perform trochoid movement in the direction of an arrow head of drawing 3, promote an inelastic collision with an electronic chlorine molecule, and the electron and ion in the plasma are increased so that the circumference of the up electrode 2 may be surrounded. The circumference of the up electrode 2 is surrounded in the shape of a ring with the plasma, and the high-density plasma in contact with the lower electrode 4 and the semi-conductor wafer 3 is formed. Furthermore, by intermittent polar reversal of an electromagnet 5, with the arrow head of drawing 3, it is reversed to hard flow and the flow direction of this plasma homogenizes the plasma. Under the present circumstances, since there is no gas supply line etc. in vertical both sides of the above-mentioned up electrode 2, the plasma can be homogenized smoothly, without checking the $E \times B$ drift motion of an electron and an ion particle.

[0027] And the up electrode 2 sets caudad, the homogenized plasma contacts the front face of the semi-conductor wafer 3, and an ion sheath is formed between a plasma field and the front face of the semi-conductor wafer 3. The electron in the plasma gives priority to this ion sheath over an ion particle, and the front face of the semi-conductor wafer 3 is arrived at, it is charged, an auto-bias is carried out to negative, and the big potential difference arises between a plasma electrical potential difference and the auto-bias electrical potential difference of the semi-conductor wafer 3. this potential difference — the ion in the plasma flies an ion sheath at high speed, it collides at right angles to the front face of the semi-conductor wafer 3, and reactive ion etching which has an anisotropy according to the exposed pattern of silicon among the semi-conductor wafers 3 is performed. Since the ion in the plasma covers all the front faces of the semi-conductor wafer 3 at this time and it is distributed over homogeneity, with ion, the front face of the semi-conductor wafer 3 is etched into homogeneity, and silicon tetrachloride gas is generated. The generation gas produced as a result of this etching is discharged from an exhaust port 12 outside.

[0028] If the plasma occurs between the up electrode 3 and the lower electrode 4 according to this example as explained above While the field B by the electromagnet 5 acts on these both 2 and the electric field E between four perpendicularly, forming the plasma of the shape of a ring which continues and goes the up electrode 2 around on the top face from an inferior surface of tongue by this rectangular electromagnetic field and carrying out densification of the plasma By change of the sense of the intermittent field B, the circumference direction of the plasma is reversed, the plasma is homogenized, the homogenized plasma can be contacted to the semi-conductor wafer 3, it can continue all over the semi-conductor wafer 3, and anisotropic etching can be carried out to homogeneity.

[0029] moreover, drawing 4 is drawing showing other examples of this invention, and it consists of this examples according to the above-mentioned example except having formed these both 2 and the plasma shielding plate 80 which prevents diffusion of the plasma generated among four in the shape of [adapted to the configuration of each above-mentioned electrodes 2 and 4] radii while it forms the up electrode 20 and a lower electrode (not shown) so that a flat-surface configuration may become circular. Therefore, also in this example, the same operation effectiveness as the above-mentioned example can be expected.

[0030] In addition, each polarity may not be reversed although the above-mentioned example explained what reverses the polarity of an electromagnet 5 intermittently.

[0031] Moreover, although the above-mentioned example explained the thing which makes it go up and down the up electrode 2 by the elevator style 7, you may make it make it go up and down the lower electrode 4.

[0032] Moreover, although the above-mentioned example explained the case where it had RF generator 43 which impresses an electrical potential difference to the lower electrode 4, this RF generator 43 may not exist, even in this case, in response to the collision of the electron in the

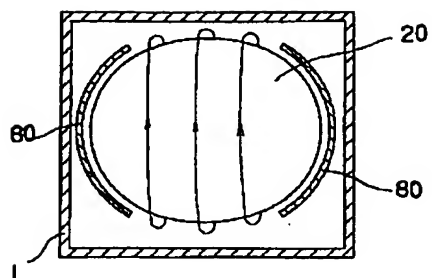
plasma, the auto-bias of the lower electrode 4 is carried out, and it can perform the same anisotropic etching as ****.

[0033] Moreover, although the above-mentioned example explained only the plasma treatment equipment used for reactive ion etching, in addition to this, the plasma treatment equipment of this invention is applicable about plasma treatment equipments, such as ashing, CVD, and sputtering, similarly.

[0034]

[Effect of the Invention] According to invention indicated to have explained above by claims 1-5 of this invention, the plasma treatment equipment which the homogeneous plasma can be contacted on the front face of a processed object, and can carry out plasma treatment of the processed object to homogeneity can be offered.

[Translation done.]



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